THE STATUS OF VASECTOMY IN THE UNITED STATES: ECONOMIC INFLUENCES AND LONG-TERM FOLLOW-UP IN MEN WITH NO CHILDREN

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by

Bobby B. Najari

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ABSTRACT

Background: Vasectomy is surgical occlusion of the vas deferens as a form of male contraception. Vasectomy is the most common non-diagnostic procedure performed by urologists in the United States. While uncommon, a childless man requesting a vasectomy can be an ethically challenging scenario for urologists. We hypothesized that men who had undergone vasectomy prior to having children would have higher rates of vasectomy reversal and family planning attitudes inconsistent with being sterile compared to men undergoing vasectomy after fathering children. We also studied the relationship between national economic conditions and men electing vasectomy.

Methods: We performed an analysis of the 2002, 2006-2010, and 2011-2013 waves of the National Survey for Family Growth (NSFG), a nationally representative survey of family planning in the United States. We compared demographic information and family planning attitudes among men who had undergone vasectomy and compared characteristics of those with vs. without children. We also performed a survival analysis of the National Survey for Family Growth 2002, 2006-2010, and 2011-2013 datasets with additional economic information obtained from the National Bureau of Economic Research and the Bureau of Labor Statistics.

Results: Of the 20,146 men surveyed, 696 (3.5%) reported undergoing a vasectomy. Of the men reporting vasectomy, 3.5% (95% CI 2.4-5.1) underwent the procedure without having had children. Compared to men with children, men without children were older at the time of vasectomy, were less likely to have ever been married, and were more likely to be agnostic or atheist. Whereas 1.3% (0.7-2.5%) of men with children underwent vasectomy reversal during the follow-up, 0% of men without children underwent reversal, p=0.441. When asked how many children they intended

to have, men without children expected 0 children, whereas vasectomized men with children expected 0.01 (95% CI: 0.0-0.2), p=0.007.

For the economic analysis, of the 20,146 men who participated in the NSFG, 7,424 men had at least one child, which using NSFG weighting methodology, is equivalent to a national population of 27,329,505 men. Of these men, 12.1 % (95% CI 10.6 – 13.7) underwent vasectomy after having a child. Using multivariate Cox proportional hazards regression, we found that compared to men in their teens, men ≥ 25 years old were almost twice as likely to undergo vasectomy after having a child [hazard ratio (HR) 1.88 (95% CI 1.29 – 2.75)]. Compared to men with 1 child, men with two children were 2.61 (95% CI 1.64 – 4.16) times more likely to undergo vasectomy and men with at least three children were 3.57 (95% CI 2.37 – 5.37) times more likely have the procedure. Compared to non-Hispanic White men, Black (HR 0.16 95% CI 0.11 – 0.25), Hispanic (HR 0.23 95% 0.16 – 0.34), and other minorities (HR 0.35 95% 0.16 – 0.77) were significantly less likely to undergo vasectomy. Men who had children born during an economic trough were more likely to undergo vasectomy, (HR 1.23 95% 1.01 – 1.52).

Conclusion: Men who undergo vasectomy without having children constitute a small but distinct population of men. During short term follow-up post vasectomy, men who have not fathered children do not express higher rates of post-vasectomy regret. In addition to demographic factors such as age and race, the economic environment influences a man's likelihood of undergoing vasectomy such that men who have children born during an economic trough are more likely to subsequently undergo a vasectomy.

BIOGRAPHIC SKETCH

Bobby Najari obtained a Bachelor of Arts with Highest Honors from The University of Texas at Austin in May 2003. He obtained his Doctor of Medicine from Baylor College of Medicine in May 2008, participating in the Medical Student Research Track. He completed his urology residency at Weill Cornell Medical College in June 2014. He is an Agency for Healthcare Quality and Research Fellow in the Weill Cornell Medical College Department of Medicine, Division of Clinical Epidemiology and Evaluative Sciences Research. He is also a Male Reproductive Medicine and Microsurgery Fellow in the Weill Cornell Medical College Department of Urology.

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CHAPTER ONE

Vasectomy in Men without Children: Demographics and Family Planning Attitudes from the National Survey for Family Growth

INTRODUCTION

In the United States, between 175,000 and over 500,000 men elect vasectomy each year.[1-3] In 2011-2013, vasectomy was the method of contraception utilized by 8.3% of women attempting to prevent pregnancy.[4] One of the strongest predictive factors positively associated with a man undergoing vasectomy is the number of children he has.[5]

Vasectomy effectively prevents pregnancy in ≥99% of men with complication rates of 1-2%.[6] It is not surprising that the procedure has a patient satisfaction rate of over 95-99%.[6] Few studies have evaluated reasons for patient dissatisfaction, however the desire for more children is the most common reported reason.[7,8] Up to 20% of men who have undergone vasectomy express a desire for more children, raising concern about the need for more comprehensive preoperative counseling that includes a discussion regarding the mutable nature of family planning intentions among men over time.[9]

Vasectomy reversal success ranges from 63% to 98%; however, even in the hands of an experienced microsurgeon, its success is far from guaranteed.[10] Therefore, vasectomy is intended to be a permanent procedure, and should be presented to patients as such.[6] There is little literature evaluating whether men who have not fathered children are at a greater risk of post-vasectomy desire for children. Guidelines on vasectomy from both the American Urological Association (AUA) and European Association of Urology (EAU) recommend caution in performing the procedure in this population.[6,11] We hypothesized that men in the United States who had undergone vasectomy prior to having children would be more likely to express desire to have children or undergo vasectomy reversal when compared to men who had already had children.

METHODS

National Survey for Family Growth

We utilized the responses of male participants in the National Survey for Family Growth (NSFG). The National Center for Health Statistics has conducted the NSFG in 8 waves every 3-7 years since 1973.[12,13] The study is performed by in-person structured interviews with a sample of men and women designed to provide nationally representative data on topics related to family growth.

The goal of the survey is to capture attitudes on marriage and divorce, pregnancy, infertility, and use of contraception in the United States non-institutionalized civilian population. Participants are recruited from 110 diverse sampling sites throughout the country, oversampling blacks, Hispanics, and teenagers. The Centers for Disease control recommends transforming the raw survey responses into national estimates using a validated methodology.[12] This transformation is performed through applying sampling weights that alter the contribution of each participant's responses in a way that the demographics of the cohort match those of the national census at the time the data was collected. The weight adjustments also account for the oversampling of minorities and teens in order to maintain a demographic that mirrors the national population. We used responses provided by men in 2002, 2006-2010, and 2011-2013 waves, which are the only waves to include men.

Sample

Inclusion Criteria

The Weill Cornell Medical College Institutional Review Board approved this study (#1601016931). Men were included in our analysis if they reported undergoing surgical sterilization with vasectomy. We then compared the demographic characteristics of men who underwent vasectomy and examined those men with children vs. those without children.

Statistical Analysis

Analyses were performed using Stata Statistical Software, Release 13 (StataCorp, College Station, TX) using the svyset procedures for use with complex survey data. Statistical significance was set at $p<0.05$. The three NSFG datasets that include men were analyzed together, so the participant weights were each divided by 3 to match the average national population throughout this time period. Demographic parameters were grouped into epidemiologically relevant categories where appropriate.9 Annual income was expressed as a percentage of the poverty limit at the time of survey, as the annual poverty limit is adjusted annually for inflation.

Demographic characteristics for men with children and without children were compared with chi squared analysis for categorical variables and linear regression for continuous variable. A multivariate analysis was performed for men undergoing vasectomy without children using variables significant on bivariate analysis. In order to determine if the demographic differences in men who have never fathered a child were simply a continuation of trends associated with the number of children a man has, an analysis was performed on the men who underwent vasectomy after zero, one, two, or at least three children using chi squared analysis. A multivariate ordinal regression analysis was performed for men with zero, one, two, and three or more children and was repeated excluding the men with no children.

Outcomes of particular interest were responses to the questions “Do you want (more) children?”, “Do you intend to have (more) children?”, and “How many (more) children do you intend to have?”. “Wanting” children and “intending” for children were distinguished with the prompt “Sometimes what people want and what they intend are different because they are not able to do what they want.” We also evaluated whether or not men in both groups had undergone vasectomy reversal.

Categorical responses were evaluated with chi squared analysis and continuous responses were compared with linear regression and multivariate linear regression.

RESULTS

Out of a total of 20,146 men who participated in the NSFG, 696 (3.5%) reported undergoing vasectomy. Projecting to the average national population from 2000 to 2012 using the NSFG sampling weights, this translates to 3,511,541 (95% CI 3,130,870 – 3,892,213) men, aged 15 - 44 years, in the United States who had undergone vasectomy. Similarly, applying the NSFG sampling weights, this population of sterilized men represent 5.7% (5.0% – 6.5%) of the national population of 61,264,844 (58,670,912 – 63,858,776) men in the nation.

Of the 696 men who participated in the NSFG and reported having a vasectomy, 27 (3.9%) men reported having no children. On a national level, applying the NSFG sampling weights, this rate would be equivalent to a national population of 122,040 (56,204 – 187,876) men undergoing surgical sterilization without having a child, which is 3.5% (95% CI: 2.0 – 5.9%) of the men with vasectomy. The remaining 3,389,501 (95% CI: 3,015732 – 3,763,270) men had vasectomies after having fathered at least one child.

Comparison of vasectomized men with and without children

There were significant demographic differences between the vasectomized men with and without children (Table 1.1). Men in both groups were surveyed at a similar age of 39 years. However, men with no children were significantly older than men with children [35 years (95% CI: 33.5 – 37.2) vs. 33 (95% CI: 32.3 – 33.2), $p = 0.01$]. Men with no children had a significantly higher annual household income at 429% of the poverty line (95% CI: 400.2% – 457.5%) compared to men with children 334% (95% CI: 319.2% – 348.5), $p < 0.001$. Both groups of men had similar rates of employment at 93-94%, and similar education levels. Men with no children were

significantly more likely to have never been married [18% (95% CI: 7.8 – 34.8) vs. 1% (95% CI: 0.7 – 1.8), p<0.001]. Religion also differed significantly between the two groups; men with no children were more likely to be agnostic or atheist [48% (95% CI: 29.9 – 67.4) vs. 15% (95% CI: 11.4 – 18.4), p < 0.001].

Table 1.1: Demographic Differences between Men Who Undergo Vasectomy with and without Children

Factor	Children National Average (95% CI)	No Children National Average (95% CI)	Univariate p value	Multivariate[a] Odds Ratio (95% CI)
Age at Survey, years	39 (38.5-39.3)	39 (37.8-40.1)	0.941	Not included
Age at Vasectomy, years	33 (32.3-33.2)	35 (33.5-37.2)	0.01	1.1 (1.0-1.2)
Income, % of poverty limit	334 (319.2-348.5)	429 (400.2-457.5)	<0.001	1.06 (1.03-1.10)[b]
Religion			<0.001	
Protestant, %	60 (54.6-64.4)	14 (5.7-28.5)		Reference
Catholic, %	21 (16.7-25.4)	31 (12.5-58.1)		9.2 (2.1-39.8)
Other, %	5 (3.3-7.8)	7 (2.3-21.0)		15.6 (3.3-76.0)
None, %	15 (11.4-18.4)	48 (29.9-67.4)		28.5 (10.7-76.1)
Marital Status			<0.001	
Married, %	87 (83.6-89.2)	73 (54.0-85.8)		Reference
Separated/Divorced, %	12 (9.8-15.2)	10 (2.6-30.9)		0.5 (0.1-2.5)
Never Married, %	1 (0.7-1.8)	18 (7.8-34.8)		35.6 (7.7-164.6)
Race			0.628	Not included
Non-Hispanic White, %	86 (82.8-88.2)	87 (72.2-94.1)		
Hispanic, %	4 (2.8-5.8)	4 (2.7-6.5)		
Black, %	4 (2.8-5.8)	4 (2.7-6.5)		
Other, %	3 (1.5-5.8)	5 (1.0-23.4)		
Education			0.252	Not included
Less Than HS, %	9 (5.4-13.3)	0		
High School, %	54 (48.4-60.2)	45 (26.9-65.1)		
College, %	37 (31.9-42.5)	55 (34.9-73.1)		

[a]Multivariate model for undergoing vasectomy with no children. [b]By increments of 10%.

Employing multivariate logistic analysis, we found that older age at vasectomy, higher income, religion, and marital status remained significantly associated with undergoing vasectomy without having fathered children (Table 1.1). Compared to men who were married, men who were never married were 35 times more likely to have not have never fathered a child before undergoing vasectomy. All non-Christian Protestant religions were significantly more likely to have undergone vasectomy without having a child compared to Protestants, with atheist/agnostic men having the largest odds ratio of 28.5 (95% CI: 10.7 – 76.1). The analysis was similar when all variables were included, with race and education not being significantly associated with undergoing vasectomy without having a child.

Comparison of men who underwent vasectomy after one, two or at least three children

An analysis was performed on the men who underwent vasectomy after zero, one, two, or at least three children and was repeated with excluding the men with zero children (Table 1.2). Unlike the analysis which included men with no children, there was no difference in the religion of the three groups with children, with 0.6% – 6.2% identifying as agnostic or atheist, ($p = 0.817$). In the group with children, age increased with number of children. Specifically, as the number of children increased from one to two to at least three, the age at vasectomy significantly increased [32.0 years (95% CI: 30.1 - 33.9) vs. 31.7 (95% CI: 30.9 - 32.6) vs. 33.4 (95% CI: 32.8 - 34.0), $p = 0.002$]. There was no difference between the number of never married men with two or at least three children [0.6% (95% CI: 0.3 - 1.4) vs. 0.6% (95% CI: 0.2 - 1.4)]. However men with one child were more likely than the men with more children to have never married [6.2% (95% CI: 3.1 – 12.3), $p<0.001$]. Finally, as the number of children increased, the annual household income significantly decreased ($p<0.001$), (Table 1.2).

Table 1.2: Men with No Children Have Religious Differences Distinct from Trends Related to Number of Children

Factor	No Children National Average (95% CI)	1 Child National Average (95% CI)	2 Children National Average (95% CI)	≥3 Children National Average (95% CI)	All Men p value	Men with Children p value
Percentage of Men with Children, %	3.5 (2.4-5.1)	9.1 (6.4-12.6)	30.6 (25.7-36.1)	56.8 (51.0-62.5)		
Age at Survey, years	39 (37.8-40.1)	38.9 (37.7 - 40.1)	38.5 (37.9 - 39.2)	39.1 (38.6 - 39.6)	0.545	0.348
Age at Vasectomy, years	35 (33.5-37.2)	32.0 (30.1 - 33.9)	31.7 (30.9 - 32.6)	33.4 (32.8 - 34.0)	<0.001	0.002
Income, % of poverty limit	429 (400.2-457.5)	415.0 (385.0 - 445.0)	345.0 (326.2 - 363.8)	314.9 (294.4 - 335.3)	<0.001	<0.001
Religion					**0.013**	**0.817**
Protestant, %	14 (5.7-28.5)	60.9 (43.7 - 75.7)	58.4 (49.2 - 67.0)	60.1 (54.0 - 65.8)		
Catholic, %	31 (12.5-58.1)	21.1 (10.1 - 39.2)	20.0 (12.4 - 30.6)	21.1 (16.4 - 26.7)		
Other, %	7 (2.3-21.0)	0.9 (0.1 - 6.0)	5.4 (3.0 - 9.5)	5.6 (3.1 - 9.8)		
None, %	48 (29.9-67.4)	17.1 (10.4 - 27.0)	16.2 (11.0 - 23.3)	13.2 (9.3 - 18.4)		
Marital Status					<0.001	<0.001
Married, %	73 (54.0-85.8)	77.6 (63.6 - 87.3)	84.2 (78.6 - 88.6)	89.4 (85.7 - 92.2)		
Separated/Divorced, %	10 (2.6-30.9)	16.2 (7.9 - 30.1)	15.2 (10.9 - 20.7)	10.0 (7.3 - 13.6)		
Never Married, %	18 (7.8-34.8)	6.2 (3.1 - 12.3)	0.6 (0.3 - 1.4)	0.6 (0.2 - 1.4)		
Race					0.725	0.654
Non-Hispanic White, %	87 (72.2-94.1)	89.5 (76.9 - 95.6)	86.4 (81.4 - 90.2)	84.8 (80.4 - 88.3)		
Hispanic, %	4 (2.7-6.5)	7.4 (2.4 - 20.6)	7.5 (5.1 - 10.9)	7.0 (5.4 - 9.0)		
Black, %	4 (2.7-6.5)	3.1 (0.9 - 10.1)	4.2 (2.3 - 7.6)	4.2 (2.7 - 6.4)		
Other, %	5 (1.0-23.4)	0	1.8 (0.6 - 5.3)	4.1 (1.8 - 9.0)		
Education					0.293	0.329
Less Than HS, %	0	7.4 (2.5 - 20.0)	5.7 (2.4 - 12.9)	10.3 (5.9 - 17.5)		
High School, %	45 (26.9-65.1)	66.0 (48.5 - 80.0)	51.9 (43.8 - 59.9)	53.8 (45.9 - 61.5)		
College, %	55 (34.9-73.1)	26.6 (14.5 - 43.6)	42.4 (34.5 - 50.7)	35.9 (28.5 - 44.0)		

A multivariate ordinal regression analysis was performed for men with zero, one, two, and three or more children and was repeated excluding the men with no children (Table 1.3). Age, income, and marital status were consistent factors

associated with number children in both analyses. However, in the analysis of only men with children, religion was not associated with number of children.

Table 1.3: Multivariate Analysis of Vasectomy

Factor	Multivariate All Men Cumulative Odds Ratio (95% CI)	Multivariate Men with Children Cumulative Odds Ratio (95% CI)
Age at Vasectomy, years	0.93 (0.89-0.97)	0.91 (0.87-0.95)
Income, % of poverty limit	1.04 (1.03-1.06)	1.04 (1.02-1.06)
Religion		
Protestant, %	Reference	Reference
Catholic, %	1.0 (0.6-1.6)	0.8 (0.5-1.4)
Other, %	1.0 (0.5-2.0)	0.8 (0.4-1.7)
None, %	2.0 (1.2 - 3.2)	1.3 (0.8-2.2)
Marital Status		
Married, %	Reference	Reference
Separated/Divorced, %	1.1 (0.6-1.9)	1.1 (0.7-1.9)
Never Married, %	13.3 (5.5-33.2)	9.4 (2.8-32.1)
Race		
Non-Hispanic White, %	Reference	Reference
Hispanic, %	1.1 (0.7-1.8)	1.3 (0.8-2.2)
Black, %	0.8 (0.4-1.6)	0.8 (0.4-1.6)
Other, %	0.5 (0.2-1.5)	0.4 (0.1-1.2)
Education		
Less Than HS, %	Reference	Reference
High School, %	1.2 (0.5-2.9)	1.1 (0.4-3.0)
College, %	1.4 (0.5-4.0)	1.3 (0.4-4.1)

Family planning outcomes: wanting children, intending to have children, or undergoing vasectomy reversal after undergoing vasectomy

We evaluated family planning outcomes among the men who underwent vasectomy (wanting children, intending to have children, or undergoing vasectomy reversal). For this analysis, men were categorized as having no children, one child,

and at least two children (men with 3 or more children had similar outcomes to men with two children). The men with no children (who were older at the time of vasectomy) had a shorter time between vasectomy and survey completion compared to men with one or at least two children [47 months (95% CI: 30.8 – 63.4) vs. 88.8 (95% CI: 60.7 – 116.8) vs. 79.9 (95% CI: 73.0 – 86.9), p = 0.002). There were no differences between the three groups in regards to wanting children, intending to have children, or undergoing vasectomy reversal (Table 1.4). Of note, none of the men who underwent vasectomy without children underwent vasectomy reversal or intended to have more children by the time of survey completion. The number of children that the childless men intended to have was significantly lower than men with one or two or more children [0 vs. 0.02 (0.0 - 0.06) vs. 0.01 (0.0 - 0.02), p = 0.024]. However, on multivariate linear regression, including age at vasectomy, household income, religion, and number of children, only age at vasectomy was inversely associated with number of children the man intended to have (correlation coefficient -0.02, 95% CI: -0.04 – 0.0), p=0.045).

Table 1.4: Difference in Family Planning Attitudes by Number of Children

Family Planning	**No Children**	**1 Child**	**≥2 Children**	**p value**
Want to have (more) children?, %	12.1 (3.6 - 33.6)	27.5 (15.0 - 44.8)	21.8 (18.0 - 26.0)	0.438
Intend to have (more) children, %	0	2.1 (0.4 - 9.9)	0.5 (0.1 - 1.7)	0.278
How many children intend to have, #	0	0.02 (0.0 - 0.06)	0.01 (0.0 - 0.02)	0.024
Underwent vasectomy reversal, %	0	2.1 (0.4 - 9.9)	1.3 (0.6 - 2.6)	0.717

DISCUSSION

This is the first population-based characterization comparing men who underwent vasectomy with vs. without having fathered children and their outcomes Men who elect surgical sterilization with no children have distinct demographic

differences from men who do so after having children. Compared to men with children, men without children are more likely to not be married [OR 35.6 (95% CI 7.7-164.6)], report no religious affiliation [OR 28.5 (95% CI 10.7-76.1) and have a higher household income [OR 1.06 (95% CI 1.03-1.10)].

When we evaluated which of these demographic differences were unique to men with no children, rather than a continuation of trends associated with the absolute number of children, the two variables that were unique to men with no children were religion and age. Almost half of the men who underwent vasectomy without having children were agnostic or atheist, compared to 15% of the men with children. This may reflect the emphasis many religions place on having children. For example, in traditional Roman Catholic, Judaic, and Islamic teaching, vasectomies are forbidden, which explains why men in these groups undergo vasectomy at lower rates than Christian Protestants and non-religious men.[9]

Men who underwent vasectomy without having children were also older than the sterilized men with children. Their older age is in contrast to the sub-analysis of men with children, in which age was positively associated with the number of children. Men who undergo vasectomy with no children may be older because of a reluctance of urologists to perform the procedure in younger men. Both the AUA guidelines and EAU guidelines recommend caution in performing vasectomies in men without children. Whether men without children wait until an older age to seek surgical sterilization out of innate reasons or because of reluctance on the part of urologists to perform the procedure on them cannot be answered by our data. Despite being older than the men with children, almost a fifth of men who underwent vasectomy without children were never married. Only 1% of vasectomized men with children were never married. The decision to undergoing vasectomy with no children demonstrates a willingness to forgo part of the nuclear family of husband, wife, and

children that was predominant in United States prior to the last half of the 20th century.[14] The fact that 18% of the men who undergo vasectomy with no children have also never been married may reflect that these men are less likely to identify with this traditional family structure.

Household income was significantly higher in the population of sterilized men with no children compared to men with children. Rather than being a unique difference in the population of men without children, the difference in income was a continuation of the trend that households with more children have lower household income. The negative correlation between number of children and income is well documented in the United States population, and is likely the result of the interplay between education attainment on both earning potential and timing of children.[15,16]

With regard to family planning intentions, vasectomized men with no children expressed family planning attitudes inconsistent with being sterile at similar rates as men with children. In fact, the men with children expressed the intention to have more children in the future far more often than the men with no children. None of the men without children reported undergoing vasectomy reversal. They also did not express the desire for more children at a higher rate. These findings suggest that, over short-term follow-up (an average of 47 months post-vasectomy), men without children in this cohort may not have experienced post-procedure regret.

Few studies have evaluated risk of future regret after vasectomy. Potts et al. retrospectively reviewed the charts of 365 men who underwent vasectomy and 290 men who underwent vasectomy reversal.[17] They found that men who underwent vasectomy in their 20s were 12.5 times more likely to subsequently undergo vasectomy reversal. However, whereas men without children constituted 4.4% of the men who underwent vasectomy, they comprised only 0.4% of men undergoing vasectomy reversal. The authors conclude “Contrary to traditional belief, our study

suggests that men with no children at the time of vasectomy were less likely to undergo vasectomy reversal later. Thus, we believe that these men may represent a group who are highly motivated to remain childless." Our findings support this hypothesis.

Holman et al. reported a population based study of Western Australia which included 28,246 men who underwent vasectomy.[18] While the overall risk of undergoing vasectomy reversal was 2.4% at 10 years, this risk was 11.1% in men in their early twenties and 6.2% for men in their late twenties. Number of children was not included in the analysis, and yet this study is cited in statements that include both young age and lack of children as risk factors for post-vasectomy regret.[11,19] While age and number of children are often positively correlated, the literature only supports young age as a risk factor for post-vasectomy regret.

The AUA guidelines on vasectomy were released in 2012 and revised in 2015.[6] The guidelines state that surgeons should exercise clinical judgement to determine the appropriateness of performing a vasectomy on any particular patient. The guidelines further state that surgeons should take into account patient age and number of children as these may be associated with patient satisfaction and absence of regret. The 2012 EAU guidelines state that there are no absolute contraindications, but that relative contraindications include the absence of children, age <30 years, severe illness, no current relationship, and scrotal pain.[11] While some of these recommendations are supported by the literature, absence of children is not, and this particular recommendation is correctly labeled as being obtained from expert committee reports or opinions or clinical experience of respected authorities.

Few men undergo vasectomy without having children. Only 3.5% of the men who reported undergoing vasectomy in the NSFG did so without having children. However, urologists who perform a high volume of the procedure, or who are in

practice long enough, will likely encounter this situation. When counseling a man who is seeking vasectomy without having children, this data is reassuring that the absence of children does not portend future regret. An additional option that can be offered to these men include sperm banking, which allows for the option of assisted reproductive technology in the event of post-vasectomy regret. Furthermore, high volume reproductive medicine centers often work with psychologists who play an important role in evaluating and counseling patients on family planning decisions. These health care professionals can helpful in confirming to both the urologist and the patient that surgical sterilization is being performed with the full understanding of its consequences.

Our study is not without limitations. The data used in our analysis is derived from only the 696 men in the NSFG reported undergoing vasectomy, and this low number potentially diminishes the accuracy which the population is described. However, the NSFG is intended to estimate the demographics of the United States, and thus the low number of men who reported undergoing vasectomy reflects the relatively low utilization throughout this country. On a similar note, only 3.9% of the vasectomized men in the NSFG had no children. However, this is similar to the 4.4% of men reported in the study from Ohio.[17] Despite the small numbers, the power remained such that important demographic differences were detected. Additionally, the period between vasectomy and survey was significantly shorter for the group of men who underwent vasectomy without children. While the follow-up period in this group was four years, it's possible that if the follow-up period were extended further, more men without children would express family planning attitudes consistent with post-vasectomy regret. In a meta-analysis of over 6,000 men undergoing vasectomy reversal, the average duration between vasectomy and reconstruction was 7 years for all studies, with the shortest average duration being 3.7 years.[10] Lastly, the NSFG only

surveys men younger than 45. Thus the survey underrepresents men older than this who may also decide to have a vasectomy reversal. This highlights a major flaw in the NSFG study design, namely that the limitations of female reproductive biology are inappropriately applied to the male population studied. Future implementation of the NSFG should address this limitation. In the meantime, vasectomy studies that include men who have not fathered children and have longer follow-up can further elucidate the post-vasectomy outcomes of these men.

CONCLUSIONS

Men who undergo vasectomy without having children constitute a small but distinct population. Compared to men with children, men without children are more likely to not be married [OR 35.6 (95% CI 7.7-164.6)], report no religious affiliation [OR 28.5 (95% CI 10.7-76.1) and have a higher household income [OR 1.06 (95% CI 1.03-1.10)]. Men without children did not report vasectomy reversal over short term follow-up, suggesting that they did not regret the procedure more than men with children. These data suggest that men without children should be counseled carefully prior to vasectomy, but not necessarily discouraged from vasectomy, however further studies with longer follow-up are needed.

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CHAPTER TWO

Predictors of a Man Undergoing Vasectomy Include Downturns in the National Economy: A Survival Analysis of the National Survey for Family Growth

INTRODUCTION

National estimates on the number of men in the United States undergoing vasectomy each year vary between 175,000 to over 500,000.[1-3] Between 2011-2013, 8.3% of women utilizing contraception reported that they relied on male sterilization as their contraceptive method.[4] It has been previously reported that men who elect surgical sterilization have more children, higher income, more education and are more likely to be white. [5,6]

The association between national economic conditions and vasectomy has also been previously evaluated. Investigators at three academic centers in Chicago, New York, and Milwaukee retrospectively evaluated their monthly vasectomy volume from 2001 to 2011 and reported a positive correlation between their monthly vasectomy volume, which ranged from 16 to 60 vasectomies per month, and the monthly national unemployment rate.[7] The study did not include any of the patient level data. They concluded that financial pressures play an important role in family planning decisions, a reasonable conclusion given that families in the United States can expect to spend 12-25% of their before-tax income on child-rearing expenses.[8]

There are no studies that have evaluated the relationship between vasectomy and economic conditions that include both patient level data and national economic information. The objective of this study is to characterize the association of the national economic environment and the decision to undergo vasectomy. We hypothesize that higher unemployment rate and economic cycle troughs are associated with the decision to undergo vasectomy.

METHODS

Our analysis includes data obtained from the National Survey for Family Growth (NSFG) and national unemployment data obtained from the United States Department of Labor Bureau of Labor Statistics.

National Survey for Family Growth

The NSFG was designed by the National Center for Health Statistics and the survey has been conducted in 8 waves every 3-7 years starting in 1973.[9,10] The survey gathers information on family life, marriage and divorce, pregnancy, infertility, use of contraception, and men and women's health via in-person structured interviews conducted at 110 diverse sampling sites throughout the United States. Blacks, Hispanics and teens are oversampled and weight adjustments are developed and applied using a validated methodology recommended by the Centers for Disease Control.[9] In this manner, the raw sample are transformed into a nationally representative cohort. The data included in the current analysis is from the 2002, 2006-2010, and 2011-2013 waves of the NSFG, which are the only waves to include men.

Economic Environment Data

The monthly national unemployment rate for the United States for the relevant time period (January 1975 to December 2013) was obtained from the United States Department of Labor Bureau of Labor Statistics.[11] The upper and lower economic cycle halves were determined based on business cycle reference dates obtained from the National Bureau of Economic Research.[12] Economic cycle upper half begins at the midpoint between a trough and peak and ends at the midpoint between a peak and trough (See Table 2.1). Economic cycle lower half begins at the midpoint between a peak and trough and ends at the midpoint between a trough and peak (Figure 1). Figure 2 is the economic peaks and trough mapped to national unemployment rate in the United States.

Table 2.1: Dates of Upper and Lower Half of Economic Cycle

Lower Half		**Upper Half**	
Start	End	Start	End
Jan 1975	Jul 1977	Aug 1977	Mar 1980
Apr 1980	Dec 1980	Jan 1981	Mar 1982
Apr 1982	Aug 1986	Sep 1986	Nov 1990
Dec 1990	Mar 1996	Apr 1996	Jul 2001
Aug 2001	Nov 2004	Dec 2004	Sep 2008
Oct 2008	Jul 2012	Aug 2012	Dec 2013

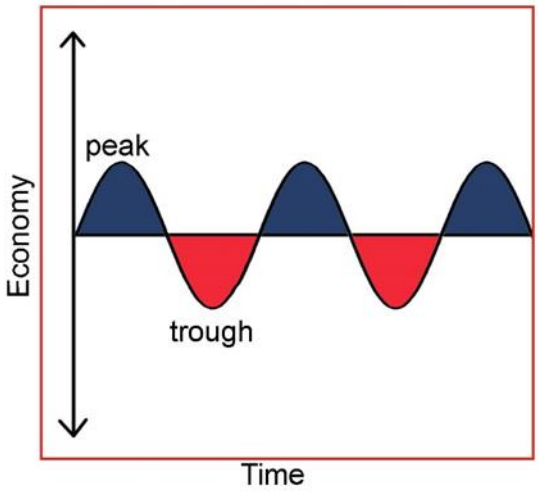

Figure 2.1: Economic Cycle Peak and Trough

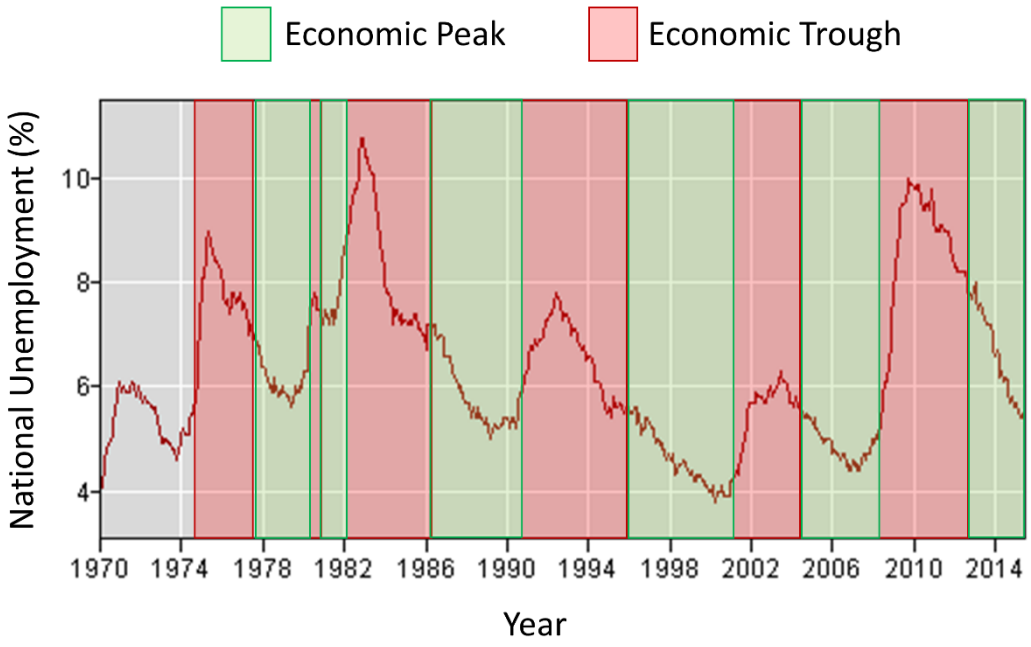

Figure 2.2: Association Between Economic Peak and Trough and National Unemployment Rate

Inclusion Criteria

This study was approved by the Weill Cornell Medical College Institutional Review Board (#1601016931). Using the NSFG data described above, we included all men who reporting having ≥ 1 children and who reported the date of their last child's birth.

Exclusion Criteria

We excluded men with no children and men with children who did not report the birthday of their last child. We also excluded men who reported having a vasectomy but did not report a date for the procedure as they could not be included in the Cox regression model.

Statistical Analysis

Analyses were performed using Stata Statistical Software, Release 13 (StataCorp, College Station, TX) using the svyset procedures for use with complex survey data. The three NSFG waves that included men (2002, 2006-2010, and 2011-2013) were analyzed together, so the participant weights were each divided by 3 to match the national population. Demographic characteristics for men who underwent vasectomy and those without vasectomy were compared with chi square analysis for categorical variables and linear regression for continuous variables. Demographic parameters were grouped into epidemiologically relevant categories based on prior studies using the NSFG dataset.[5] Subject's household income at the time of survey is included in the NSFG dataset and is expressed as a percentile of the poverty level for the year of survey as this is adjusted annually for inflation. For each participant, we calculated the average monthly unemployment rate during each study participant's follow up period (time from child's birth to subject's date of NSFG survey). Despite the NSFG not being a longitudinal study, we considered the time from last child's birth to the date of NSFG survey to be the follow up period for the purpose of a survival analysis. A multivariate Cox proportional hazards model was used to identify factors that predicted undergoing vasectomy.[13] The follow-up period for this model started eight months prior to the birth of the last child, as this is the soonest a family would know about a pregnancy and consider surgical sterilization. Undergoing a vasectomy was considered the event of interest, and men were otherwise censored at the time of the survey interview. Only variables considered constant or could be backdated to the start of the follow-up period (i.e. age, race, religion, number of children, national unemployment rate, and economic cycle) were included in the model.

RESULTS

A total of 20,146 men participated in the NSFG during the three time periods, including 4,928 men in 2002, 10,403 men from 2006-2010, and 4,815 men from 2011-2013. Of the 20,146 men, 11,020 (54.7%) were excluded because they had no children, and 1,691 (8.4%) were excluded because the date of birth of their last child was not reported. Of the 696 men who underwent vasectomy, 7 (1.0%) were excluded because the date of vasectomy was not reported. A total of 7,424 (36.9%) men met inclusion criteria and were included in the analysis.

Using the NSFG methodology, the 7,424 men who participated in the survey translates, by applying sampling weights, to 27,329,505 men (95% CI 25,976,339 – 28,682,670) in the United States between ages 15 to 44 years who had at least one child. Of this population of men, 12.1 % (95% CI 10.6 – 13.7) reported undergoing vasectomy.

Differences between men with children who underwent vasectomy vs. men who did not

There were significant demographic differences between men who underwent vasectomy vs. men who did not (Table 2.2). Men who underwent vasectomy were older at the time of survey participation (38.9 vs. 34.4 years old, $p < 0.001$). Men who underwent vasectomy were also older when they had their last child [29.7 (95% CI 29.1 – 30.3) vs. 28.4 years old (95% CI 28.2 – 28.6), $p < 0.001$]. In regards to age at the time of their last child, a greater proportion of men who had their last child after the age of 25 had vasectomies compared to younger men in their twenties and teens (14.8% vs. 12.4% vs. 7.8%, $p <0.001$).

Table 2.2: Baseline Participant Demographics

Table 2.2: Baseline Participant Demographics

	Proportion of Population, % (95% CI)	**Proportion with Vasectomy, % (95% CI)**	**p value**
Total	n = 27,329,505	12.1 (10.6 - 13.7)	
Age at Baseline			<0.001
<20	28.2 (26.6 - 29.9)	18.2 (13.7 - 23.7)	
20-24	31.1 (29.4 - 32.8)	12.4 (10.2 - 14.9)	
>25	40.7 (38.9 - 42.6)	49.9 (43.7 - 56.0)	
Number of Children			<0.001
1	24.5 (23.1 - 26.0)	9.1 (6.2 - 13.0)	
2	30.9 (29.2 - 32.7)	12.6 (10.1 - 15.4)	
3 or more	44.6 (42.6 - 46.6)	15.9 (13.6 - 18.5)	
Race			<0.001
Non-Hispanic White	58.4 (55.8 - 60.9)	17.7 (15.5 - 20.2)	
Hispanic	22.3 (20.0 - 24.7)	3.8 (2.8 - 5.2)	
Black	13.2 (11.8 - 14.9)	3.7 (2.5 - 5.5)	
Other	6.1 (5.0 - 7.4)	5.9 (2.8 - 12.2)	
Religion			<0.001
Protestant	46.1 (44.2 - 48.0)	15.7 (13.5 - 18.3)	
Catholic	27.9 (25.9 - 29.9)	9.1 (6.8 - 12.2)	
Other	8.0 (6.8 - 9.3)	7.7 (4.7 - 12.2)	
None	18.1 (16.7 - 19.5)	9.1 (7.1 - 11.6)	
Economic Cycle			0.071
Peak	55.5 (53.3 - 57.6)	11.0 (9.3 - 12.9)	
Trough	44.5 (42.4 - 46.7)	13.4 (11.3 - 15.8)	
Marital Status			<0.001
Married	67.5 (65.6 - 69.3)	15.5 (13.6 - 17.7)	
Separated/Divorced	12.8 (11.8 - 13.9)	11.3 (9.1 - 14.1)	
Single	19.7 (18.2 - 21.2)	0.7 (0.3 - 1.4)	
Education			<0.001
Less Than HS	20.0 (18.4 - 21.6)	4.7 (3.0 - 7.5)	
High School	33.1 (31.4 - 34.9)	9.6 (7.5 - 12.1)	
Associate	24.9 (23.2 - 26.7)	13.8 (11.0 - 17.2)	
Bachelor	13.6 (12.4 - 15.0)	20.5 (16.3 - 25.5)	
Graduate	8.3 (7.1 - 9.7)	20.3 (15.9 - 25.7)	

Men who had 3 or more children were also more likely to have a vasectomy than men with two children or a single child (15.9% vs. 12.6% vs. 9.1%, p <0.001). Non-Hispanic white men were much more likely to undergo vasectomy compared to minorities (17.7% vs 3.7 – 5.9%), p <0.001). Protestants were more likely than other religions to undergo vasectomy (15.7% vs 7.7 – 9.1%, p<0.001). Single men were much less likely to undergo vasectomy compared to married and separated or divorced men (0.7% vs. 15.5 vs. 11.3%, p<0.001). The proportion of men undergoing vasectomy increased with higher levels of education (4.7% for men without a high school diploma to 20.3% for men who completed graduate school, p<0.001).

Economic differences between men with children who underwent vasectomy vs. men who did not

In regard to the economic data evaluated, men who underwent vasectomy had a higher household income level at the time of survey when compared to men who did not [333.8% of poverty line (95% CI 316.4 – 351.2) vs. [255.0% (95% CI 248.1 – 261.8), p<0.001)]. Overall, 44% men had their last child born during an economic trough, and of these, 13.4% (95% CI 11.3 – 15.8) underwent vasectomy vs. 11.0% (95% CI 9.3 – 12.9) who had a child born during an economic peak, p =0.071. The average unemployment rate during the time of follow-up was lower for the men who underwent vasectomy at 6.0% (95% CI 5.72 – 6.23) vs. 6.3% (95% CI 6.18 – 6.37), p =0.024.

Survival analysis of undergoing vasectomy after having a child

A survival analysis was performed with the last child's birth as the baseline, and vasectomy as the event (Table 2.3). The time to event (time from last child to either vasectomy or survey administration date without vasectomy) was significantly shorter for the men who underwent vasectomy compared to those who did not have vasectomy, 35.6 (95% CI 31.6 – 39.5) vs. 78.2 months (95% CI 75.6 – 80.7), p<0.001.

The time from last child to survey was longer for the men who underwent vasectomy at 116.1 months (95% CI 107.7 – 124.5) vs. 78.2 (95% CI 75.6 - 80.7) among those who did not have vasectomy. Compared to men in their teens, men aged 20-24 had a HR of 1.39 (0.94 - 2.05), and men ≥ 25 years of age had a HR of 1.88 [HR 1.88 (95% CI 1.29 – 2.75)]. Compared to men with one child, men with two children had a HR of 2.61 (95% CI 1.64 – 4.16) and men with at least three children underwent had a HR of 3.57 (95% CI 2.37 – 5.37). Compared to the rate of non-Hispanic White men, Black, Hispanic, and other minority men had a significantly lower HR for vasectomy at [0.16 (95% CI 0.11 – 0.25), 0.23 (95% CI 0.16 – 0.34), and 0.35 (95% CI 0.16 – 0.77) respectively]. Compared to Protestants, Catholics had a HR of 0.64 (95% CI 0.47 – 0.96), agnostic/atheists had a HR of 0.61 (95% CI 0.45 – 0.83), and other religions had a HR of 0.47 (95% CI 0.27 – 0.80). The two economic variables included in the survival analysis were the average unemployment rate during the follow-up period and whether or not the man's last child was born during an economic cycle peak or trough (Table 2.3). The HR for average unemployment rate during the follow-up period was not significant. However, men who had children born during an economic trough underwent vasectomy had a HR of 1.23 (95% CI 1.01 – 1.52), compared to men whose children were born during an economic peak.

Table 2.3: Risk Factors for Undergoing Vasectomy after Birth of a Child

Factor	Hazard Rate	p value
Age at Baseline		
<20	Ref	
20-24	1.39 (0.94 - 2.05)	0.092
≥25	1.88 (1.29 - 2.75)	0.001
Number of Children		
1	Ref	
2	2.61 (1.64 - 4.16)	<0.001
≥3	3.57 (2.37 - 5.37)	<0.001
Race		
Non-Hispanic White	Ref	
Hispanic	0.23 (0.16 -0.34)	<0.001
Black	0.16 (0.11 - 0.25)	<0.001
Other	0.35 (0.16 - 0.77)	0.009
Religion		
Protestant	Ref	
Catholic	0.64 (0.47 - 0.96)	0.029
Other	0.47 (0.27 - 0.80)	0.006
None	0.61 (0.45 - 0.83)	0.002
Economic Cycle		
Peak	Ref	
Trough	1.23 (1.01 - 1.52)	0.045
Average Unemployment Rate	0.93 (0.83 - 1.04)	0.202

DISCUSSION

The decision to undergo vasectomy is dependent on numerous factors. Exposure to vasectomy as a contraceptive option, either by a general practitioner or an acquaintance influences the decision.[14,15] Numerous demographic factors such as age, race, and education are also associated with a man undergoing vasectomy.[6,16] Our study suggests that a man's decision to undergo vasectomy is influenced by the economic environment in which his last child was born.

The concept that the national economy can influence the popularity of elective surgical procedures is not new.[17] Numerous studies have reported a positive

relationship between economic indices and elective plastic surgery procedures, which are often not covered by health insurance.[18-20] Even elective surgical procedures covered by health insurance, such as hip and knee arthroplasty, can be negatively affected by an economic downturn.[21] The association between the economy and elective surgical procedures is likely related to both household discretionary spending, as well as health insurance coverage. A quarter of insurers do not cover vasectomy, and during an economic downturn, employers are less likely to offer health insurance, which would also influence an individual's decision to undergo an elective procedure.[22,23]

Surgical sterilization procedures such as vasectomy in men differ from other surgical procedures in that the procedure can significantly affect a patient's financial situation by preventing future children. A husband-wife household in the United States can expect to spend an average of $176,550 on a single child from birth to the age of 18.[8] Depending on household income, a household spends $9,480 to $21,430 per year on a child. Given the significant costs associated with additional children, it seems reasonable that economic environment plays a role in a man's decision to elect surgical sterilization.

Anecdotal evidence of an increase in interest in vasectomy was noted by multiple media outlets during the most recent recession of 2008-2010.[24-26] Sharma et al. performed a retrospective chart review to identify the monthly number of vasectomies performed at three high volume academic centers and correlate that volume to various economic indicators from 2001 to 2011.[7] They reported that the monthly frequency of vasectomy procedures was correlated with the national unemployment rate during that month ($r = 0.56$ $p<0.001$). The correlation was mostly driven by an increase in procedures during the most recent recession. Limitations of that study were the short time frame of ten years, and the fact that three high volume

academic practices may not represent national trends. However, the authors' conclusion that financial pressures may be important in family planning decisions is logical.

This is the first study to evaluate the association between the national economy and the rate of vasectomy in a nationally representative sample of the United States. Previous studies have identified demographic differences between men who have undergone vasectomy and those who have not.[5,6] We found that men who have a child during an economic trough have a HR of 1.23 for undergoing subsequent vasectomy compared to men whose children were born during an economic peak. While personal factors, such as age, race, and number of children were stronger predictors of undergoing a vasectomy, our findings support the notion that the economic environment plays a role in the family planning discussions surrounding a man's decision to undergo surgical sterilization.

We evaluated two aspects of the economic environment and a man's likelihood of undergoing vasectomy: the average unemployment rate after a child's birth and whether or not that child was born in an economic trough. Using survival analysis, we found that having a child born during an economic trough increased the HR of reporting vasectomy, whereas the average unemployment rate did not. This may reflect the fact that the largest differential cost while raising a child is in the 1st year, ranging from $9,480 to $21,430 depending on income.[8] Bearing this differential cost in the environment of an economic downturn may influence one's decision as to whether a family is complete.

The idea that an economic downturn can influence a man's decision to undergoing vasectomy has important policy implications. As of 2012, a contraceptive mandate has been effective as part of the Patient Protection and Affordable Care Act.[27] The contraceptive mandate requires insurers to provide contraception and sterilization

services to women at no cost, including surgical sterilization. Male contraceptive methods, including vasectomy, are explicitly exempt from this mandate. In 2012, the average cost of a vasectomy was $708, compared to $1374 to $2912 for surgical sterilization techniques for women.[28,29] Despite the fact that vasectomies are safer, more effective, and more cost effective, women undergo surgical sterilization at three time the rate of men.[30,31] If an economic downturn influences a couple's decision to pursue surgical sterilization, the relative cost difference between surgical sterilization for a man vs. a woman may exacerbate the contraceptive burden women bear.

This study is not without limitations. The NSFG is administered to participants at one time and thus is cross sectional and not longitudinal data. However, we used a Cox proportional hazards model analyzing the time following the birth of a child for a risk of undergoing vasectomy. This introduces the potential for recall bias, as evidenced by the fact that 9% of men were excluded from the study due to lack of relevant dates. However, this methodology has been used in similar analyses of the NSFG, and we attempted to minimize recall inaccuracies by restricting the analysis to participant characteristics that are immutable with time.[13] Additionally, the NSFG only surveys men up to the age of 44, and thus excludes a population of men who have a partner of child-bearing age who may elect to undergo surgical sterilization in the future. Despite the limitations, the study represents the first examination of a relationship between national economic conditions and patient level data among men who have undergone vasectomy vs. not undergone the procedure.

CONCLUSIONS

Men who undergo vasectomy have many demographic differences compared to men who do not elect surgical sterilization. Men who elect vasectomy are older, have more children, higher household income, more education, and are more likely to be white. In addition to demographic factors such as age and race, the economic

environment influences a man's likelihood of undergoing vasectomy. Compared to men who have a child during an economic peak, men who have a child during an economic downturn have a higher HR of undergoing subsequent elective vasectomy. This may have relevant public policy implications in the context of a national contraceptive mandate that re-enforces a gender imbalance in surgical sterilization utilization.

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